

AIRS V6: NOAA's Perspective

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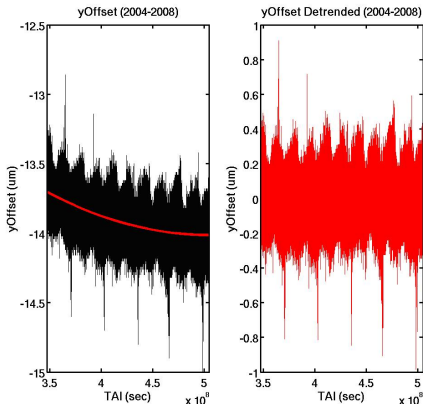
Overview of Activities

NOAA/NESDIS/STAR is currently supporting the following activities for AIRS V6 development:

- 1 Installation of the variable frequency RTA (and cloudy?).
- 2 Development and installation of an optimal estimation CO retrieval algorithm.
- 3 Upgrade of the AIRS Cloudy (minus AMSU 4, 5, 7) and First Guess Regressions using extended time period training of eigenvectors and regression coefficients over AIRS' mission.
- 4 Addition of convective parameters to AIRS L2 Standard Products.
- 5 Understanding and mitigation of spurious time-dependent trends in AIRS L2 retrievals.

In the following I will describe the status of each of these projects (as of last year) and give a workplan. I will conclude with a timeline for delivery.

Variable Frequency RTA

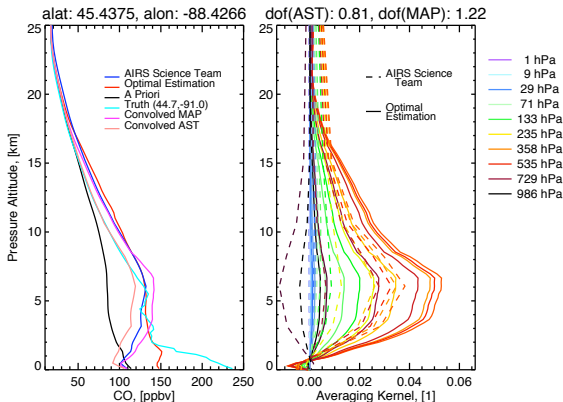


source: <http://airsteam.jpl.nasa.gov/netmeeting/200906.11.Netmeeting/AIRS.y0.v.time.jpg>.

- Need to finalize delivery of coefficients, implementation code, and “yoffsets” from NASA/JPL and/or UMBC – maybe already done?
- Should be relatively simple (mostly plumbing) to upgrade in the offline system.
- These modifications will be provided to J. Blaisdell for installation into the AIRS PGE.

Optimal Estimation CO retrieval

- Optimal Estimation CO retrieval (methodology published in [Maddy *et al.*, *IEEE GRSL*, 2009]) was delivered to UMBC on September 22, 2009.



- W. McMillan showed some first-look comparisons vs. AIRS V5 and *in situ* and gave initial impressions on Wednesday.
- Algorithm may require tweaking of the constraint matrix – this should not be complicated and will not be time consuming.

AIRS Cloudy and First Guess Regression Upgrades

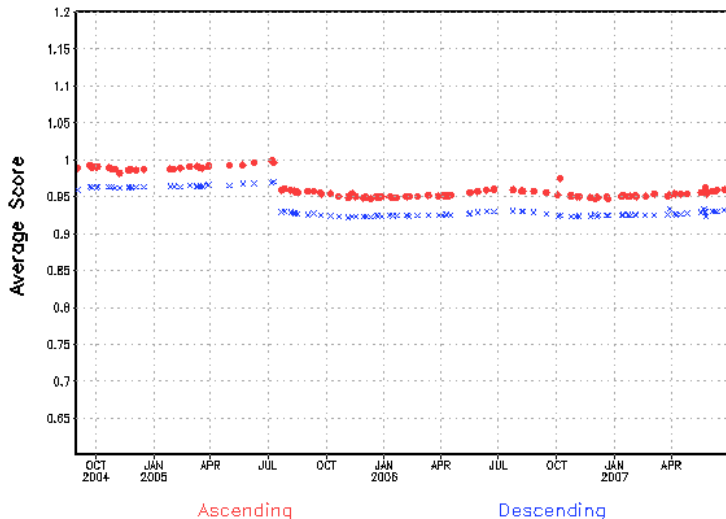
What has been done? (L. Zhou and X. Liu)

- In an attempt to mitigate time-dependent drifts, AIRS eigenvectors were re-trained using multiple days data (random + SO₂) for the time period spanning : 2003/01/01-2007/12/31 using a “pristine channel list” of 1707 channels.
- 14 days were used to calculate regression coefficients (multiple dates throughout AIRS mission between 2004 – 2007).

What have we discovered?

NRT upgrade from V3.6 to V4.0 on 07/14/2005

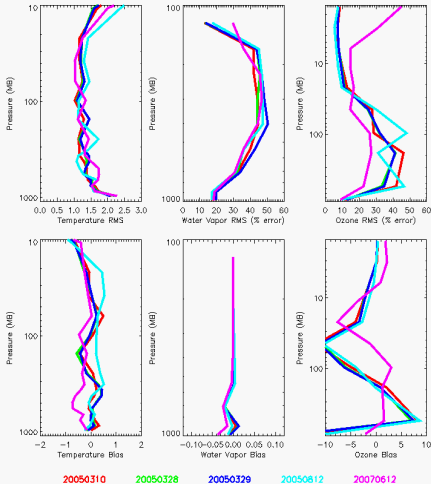
Score Time Series for 1707 Channel Set



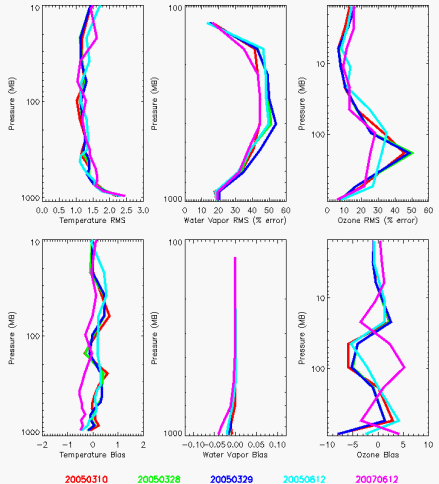
We will need to homogenize our training dataset using V5 radiances from the DAAC.

Old (left) and New (right) Regression for 4 dates

Regression Statistic Result for Ascending



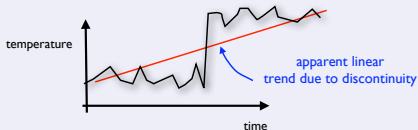
Regression Statistic Result for Ascending



Bottom left panel of each figure shows bias (purple = 2007, all other is 2005). Time dependence of new and old look very similar indicating that multiple year training does not remove temporal drifts from our regression.

AIRS Cloudy and First Guess Regression Upgrade Liens

- Current eigenvector and regression training uses a test between predicted AIRS 2390cm^{-1} and AMSU in Channels 4, 5, 6. – **Data after Oct. 2007 cannot be included in the regressions.**
- NRT upgrades (V3.6 to V4.0 compressed radiances on 07/13/2005) cause a change in PCS(t) – **The step is as large as day/night difference in PCS and is probably significant.**
- Updated regression (training from 2003 - 2007) shows a cooling trend similar to old regression between 2005 and 2007 of $0.1\text{--}0.2\text{ K / yr}$ in the troposphere (next slides) – **This may indicate that the regression PCS cannot separate time-dependent drifts due to CO_2 /ECMWF/etc. The regressions may require a time-dependent term.**
- ECMWF model changes (e.g. model resolution Feb. 2006). This change introduced a kink in the ECMWF record that results in an apparent $0.05\text{--}0.07\text{ K / yr}$ warming in the upper troposphere.



Regressions which use data before and after will be sensitive to this apparent trend.

Temporal training of regressions (non-linear or linear) require data more temporally stable than ECMWF.

Stability Indices in AIRS L2 Standard Product

- NOAA has a subroutine in our offline system that calculates various convective/stability parameters (e.g., CAPE, CINH, EL, LFC, LCL, etc.) from AIRS 100 layer L2 - presented in previous meetings (work performed by F. Sun).
- **Problem: AIRS L2 Standard Product does not have sufficient vertical resolution to accurately calculate these stability indices.**
- We propose to provide this subroutine to J. Blaisdell for incorporation into the PGE and have the outputs included in the AIRS standard product.
- The code offers some flexibility in the choice of derived parameters and details will need to be discussed.

Spurious Trends in AIRS L2

A large portion of NOAA's focus has been on the mitigation and understanding of spurious trends in AIRS L2 retrievals.

Summary of Findings

- AIRS L2 T(p) retrievals have been trending at roughly 0.1K/yr.
- We have determined that the increase in atmospheric CO₂, a possible feedback on the CO₂ noise-covariance term, and the (in)separability between T(p)/CO₂ is responsible for \approx 50-75% of the observed trend.
- N₂O is a small component \approx 20-30mK/year (next slides).
- We have trained a regression using AMSU channels regressed onto ECMWF (or NCEP GFS) T(p) (Mitch's idea) – trends of these regressions (2002-2008) are between 20-30 mK/yr.
 - the sonde database (2002 - 2008) can distinguish trends at the 20-30mK/yr level.
 - AMSU might be a small component < 20-30mK/year.

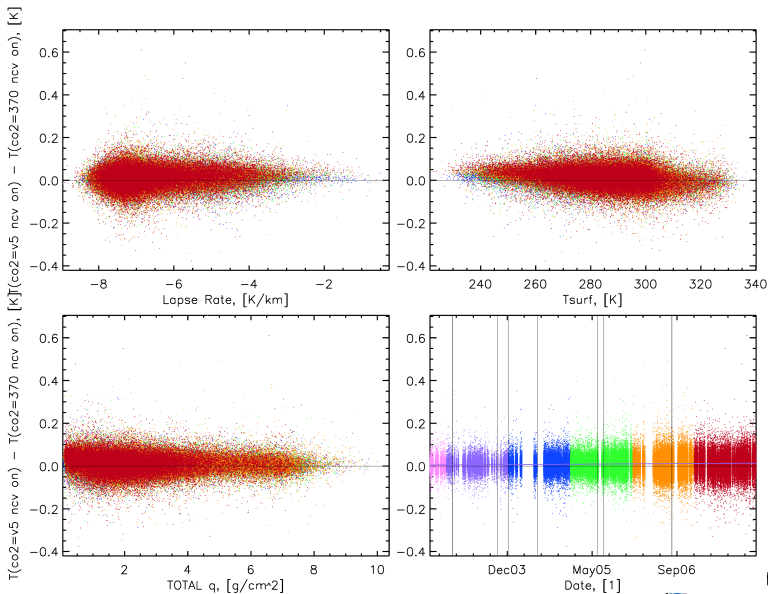
Methodology to Determine Trends Magnitudes Due to Potential Changes to V5x

- Use V5x retrieval system without regressions – NCEP GFS forecast/analysis fields for initialization.
- Make a change (list below) to the retrieval system and calculate the mean difference between retrieval T(p)'s (3-10km) for the operational sonde time-dependent data set.
 - Retrieval-minus-retrieval differences removes uncertainties in retrievals - sondes, sondes, etc.
 - The NOAA operational radiosonde database is currently used due to our familiarity with the dataset.

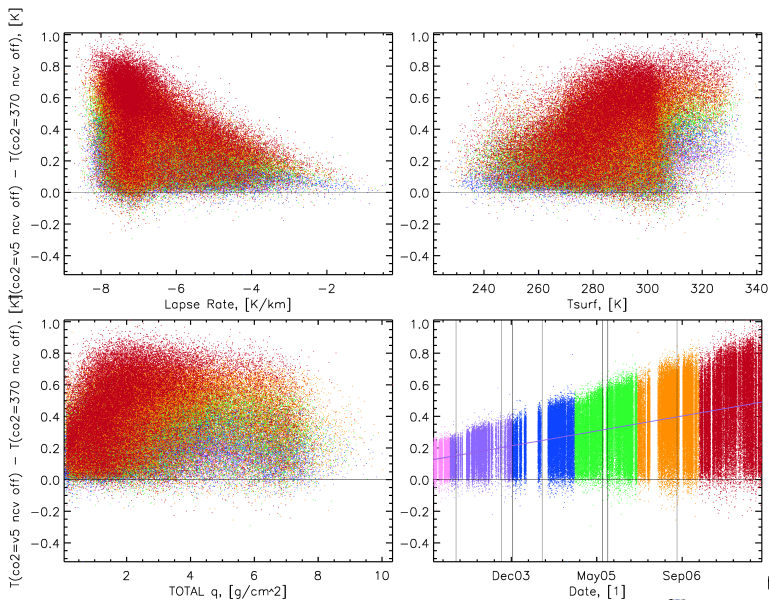
Retrieval changes investigated.

- 1 N₂O initialization: increase of $\approx 0.2\%/yr$ with and without CO₂ noise-covariance term.
- 2 CO₂ initialization: V5 linear ramp or V4 constant 370 ppmv with and without CO₂ noise-covariance term.

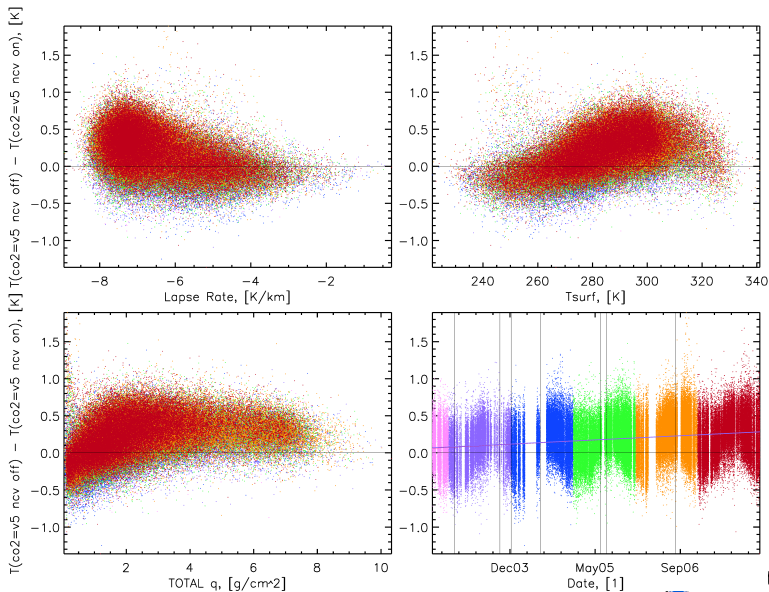
The Effect of Including CO₂ Increase with CO₂ NCV On



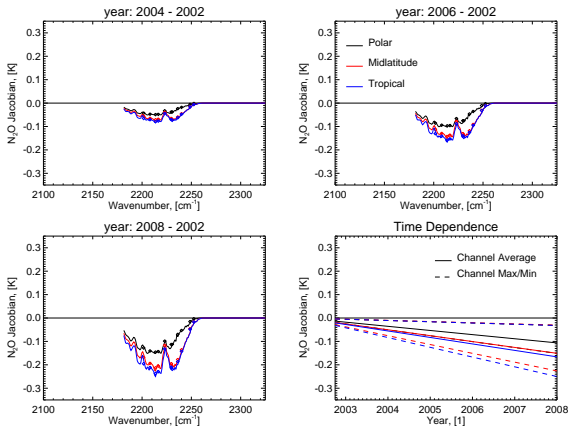
The Effect of Including CO₂ Increase with CO₂ NCV Off



The Effect of the CO₂ NCV with V5 linear CO₂ ramp



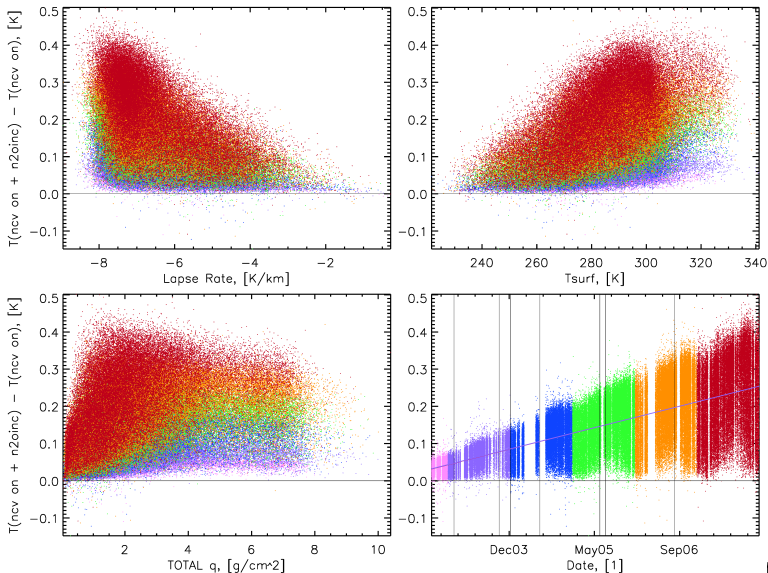
The Effect of The Temporal N_2O Increase on AIRS Radiances For Tropical, Midlatitude, and Polar Atmospheres. V5.0 Temperature Channel Marked By Diamonds.



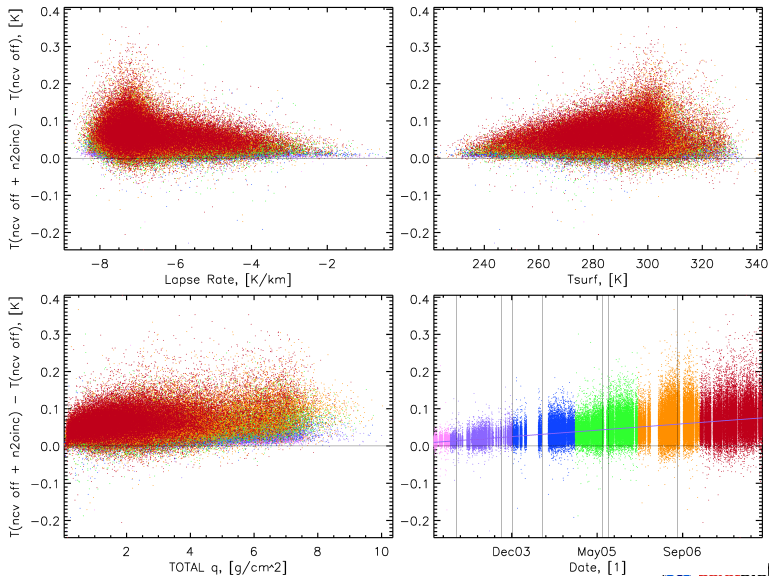
In the bottom right panel we show the time dependence of the average of N_2O sensitive channels and the time dependence of the max/min N_2O sensitive channels in order to give an idea of the range of spectral sensitivity to N_2O variability.

Second pass ($6.3 \mu\text{m}$) temperature channels also sensitive to N_2O albeit at 50% of this level.

The Effect of Including N_2O Increase with CO_2 NCV On



The Effect of Including N₂O Increase with CO₂ NCV Off



Recommendations

- The RTA and retrieval systems are very sensitive to CO₂ and N₂O initialization. We have recommended removal of N₂O sensitive channels for T(p) steps (CO and N₂O overlap think the cross-talk is small between these gases) – **provided GSFC with a list of N₂O sensitive channels.**
- A CO₂ climatology is required to ensure temporal stability of AIRS L2 (NOAA has one, GSFC or JPL may have something as well) – **AIRS L2 retrievals (mainly T(p) and cloud retrievals) are sensitive to CO₂ inputs – requires testing and ability to predict future CO₂ values.**

Bottom Line(s): Many things can introduce time-dependent trends in AIRS L2 retrievals. Candidate systems will require testing to ensure temporal stability with regard to changes (NCV on/off, channels, CO₂, etc.).

Timeline - Pending MOU Status

- 1 Installation of the variable frequency RTA (and cloudy?). - roughly 1/2 year allocated - John wants this in stages (ν -shift first, followed by cloud RTA).
- 2 Development and installation of an optimal estimation CO retrieval algorithm. - (already provided to W. McMillan, will provide support during testing phases).
- 3 Upgrade of the AIRS Cloudy (minus AMSU 4, 5, 7) and First Guess Regressions using extended time period training of eigenvectors and regression coefficients over AIRS' mission. - 1-2 months for development will provide to J. Blaisdell for testing.
- 4 Addition of convective parameters to AIRS L2 Standard Products. - (code already written can provide to J. Blaisdell for incorporation into PGE).
- 5 Understanding and mitigation of spurious time-dependent trends in AIRS L2 retrievals. - open-ended ... we know many things can cause or remove trends, we need to determine what